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AUTHOR Winn, Bill; And Others
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ABSTRACT

Two distance education courses presented via teleconferencing by the University of Calgary were redesigned to include graphic support utilizing Canada's Telidon videotex system. Data were gathered on both the instructional effectiveness of and student responses to the graphics. While the evaluation pointed out a number of features that needed to be modified in the system, it also revealed aspects of a computer graphic that make it effective. This report provides a brief overview of instructional graphics, describes the Calgary experience with Telidon page design, and looks at ways in which instructional graphics can be used to control various aspects of instruction. Conclusions indicate that the Telidon system lends itself well to the presentation of simplified graphic materials for illustrations, cueing, and structures, and that the use of such graphics to control the flow of instructional activities is very effective. Although limitations imposed by text size when the monitor is used with groups of students would make more complex and detailed graphics illegible at the present time, future developments leading to more sophisticated computer graphics systems will allow more complex animation and screen resolution in the future. A list of references completes the document. (JB)

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Designing Computer Graphics: An Experiment in the Graphic Enhancement of Audio Teleconferencing.

Bill Winn

Emma Plattor

Judy Loosmore

The University of Calgary.

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The purpose of this paper is to describe a two-year project concerned with the development and evaluation of two distance education courses in which Canada's Telidon videotex system was used in conjunction with audio teleconferencing. A brief description of the system and of the project will be given. The main emphasis in the paper, however, is on the design of effective computer graphics, and the ways in which they can be used by instructors to exercise certain types of control over learning activities. During the course of the project, we have gained a lot of experience in this area, and have made a number of discoveries about designing graphics for this type of system, many of which fly in the face of what we already knew about graphic design, and also often in the face of common sense.

The System.

Like many Universities, the University of Calgary takes its responsibility for offering off-campus courses very seriously. The Faculty of Continuing Education teaches a large number of credit and non-credit courses to students who are unable to attend regular courses on campus. Many of these students are located at considerable distances from the University throughout the Province of Alberta. Teleconferencing, using the telephone, delivers a large number of courses to these people. The University has a Teleconference Center on campus, and a large number of centers located in communities throughout the Province.

The teleconferencing system is completely interactive. The centers are connected through a "Bridge" to a studio on campus, where the instructor teaches. Up to 20 centers can be connected at once. Microphones in the centers permit students to talk back to instructors at any time during a session simply by pressing a "talk bar". Thus, there is the potential for as much interaction during a session as there would be in a normal classroom. We have found that students quickly learn to be at ease with the system and take advantage of the ability to interrupt the instructor to make comments and ask questions.

Of course, the teleconferencing system, like any other used to teach students at a distance, trades off a number of the advantages of regular classroom instruction for accessibility to courses by students who would not otherwise be able to take them. Traditionally, one facet of instruction that has been compromised has been the visual supports provided by chalkboards, overhead projectors, slides, and so on. Some teleconferencing instructors can manage very well without these. Others are less able to. Attempts to overcome this problem have, at best, been cumbersome and only marginally successful. For example, overhead transparencies have been sent out by mail, to be projected by someone in the centers on cue from the instructor. Large numbers of handouts have been mailed out to be used during the sessions,

which has been costly and vulnerable to the vagaries of the postal system.

The availability of computer-based systems for the creation, storage and distribution of text and graphic material offered an alternative method for distributing and using graphic support during teleconferencing sessions. In particular, Canada's Telidon system (currently referred to as NAPLPS, North American Presentation Level Protocol Syntax), which became available at about the time we were beginning to look at methods of graphic enhancement for teleconferencing, offered the range of textual and graphic features we needed. The version of Telidon that we used (more recent versions of NAPLPS offer considerably more features), offered eight colors, eight shades of grey, a variety of textures, four sizes of print and in single or double height, a number of "primitives", such as circles, rectangles, and so on, and the ability to draw polygons of any shape, all of which could be filled or left empty. By the standards of more recent systems, this may not appear to be particularly generous. However, these features were perfectly adequate for our project.

Computer software for the creation, editing and display of Telidon "pages" was written, and the programs and database were run on a VAX 1170 computer with the UNIX operating system. All software was written in the C programming language. Further technical aspects of the system are described elsewhere (Winn, Ellis, Plattor, Sinkey and Potter, 1984, 1985; Winn, Ellis and Sinkey, 1983; Plattor and Winn, 1983).

The Project.

Two courses that lent themselves particularly well to graphic support were concerned with the teaching of grammar, and with classroom management. Both of these were "quarter courses", involving 20 hours of instruction to inservice teachers, once a week over a seven-week period. For the project, these courses were completely redesigned in order to take advantage of the Telidon component.

The development team, consisting of subject-matter specialists, graphic designers, computer programmers and telecommunications people, followed fairly standard procedures of instructional development. These are described in detail in Winn et. al. (1985). Of particular relevance to this paper are the procedures employed for the design and production of the graphics. This began with a graphic designer and a subject-matter specialist discussing which aspects of a particular session should be visualized and how that might be accomplished. Often, a sketch of a possible graphic was produced on the spot. If not, sketches were prepared later and shown to the subject-matter specialist for changes or for approval. From the sketches, Telidon pages were developed, following principles of good

graphic design, and the pages were entered into the database. These were subsequently screened by the subject-matter experts with the graphic designer. Often pages would go through a number of revisions before they were judged suitable, or were rejected.

Once the pages for a course had been created, they were evaluated for clarity, accuracy of content, and appeal by senior students or teachers who were familiar with the content. (It was impractical to test formatively each of the complete courses before they were offered. However, modifications were made, particularly in the grammar course, after the first offering.) Every graphic was scrutinized in this way, and further revisions and rejections occurred subsequently.

The grammar course was offered in the Fall of 1982 and in the Spring of 1983 in 16 centers with 55 students. The classroom management course was offered in the Winter of 1984 in 11 centers with 36 students. On each occasion, extensive evaluation was carried out, the detailed results of which have been reported elsewhere (Winn et. al., 1984, 1985).

A variety of techniques were used to gather data on the effectiveness of the system. These included questionnaires, journals kept by students during and after the course, observation of class sessions both in the studio and in the centers, written comments, participants' assignments, assignments the participants gave their own students, and so on. The data that we gathered allowed us to conclude that the system was satisfactorily reliable, that students achieved the course objectives, that they liked the graphic enhancement but that they also liked handouts to take away with them, that they took notes from the Telidon screen, that overall they thought the system was superior to other distance-education systems they had encountered, but still not quite as satisfactory as face-to-face instruction on campus.

Summary.

We developed a system of graphic enhancement for teleconferencing that was successful. The system involved no CAI or CMI (though there is no reason why it should not). Rather, we used a computer for the creation, storage and distribution of a text and graphic database designed to support two courses for teachers. The evaluation pointed out a number of features that needed to be modified in the system. What is more important, though, is that it revealed a lot about what makes a computer graphic effective. It is to this that we now turn.

Computer Graphics.

This section of the paper will present our thoughts on the use of computer graphics, especially Telidon pages, as visual support for instruction. A great deal of what is known about the effectiveness of various forms of illustration to accompany spoken and printed language is as equally applicable to computer graphics as it is to the preparation and use of graphics supported by other media. Indeed, these general principles (see for example Fleming and Levie, 1978; Winn and Holliday, 1982) derived from research as well as from experience in the design and use of graphics for instruction, were our starting point for the design of our Telidon pages. However, as we discovered, a number of these principles just did not seem to work when we came to apply them. Not a lot has been written about the special considerations one must bear in mind when working with computer graphics. A chapter by Reynolds (1982) is an exception, and while we did not use her observations as prescriptions for designing Telidon pages, her comments support, in retrospect, what we discovered for ourselves.

We begin with a brief overview of instructional graphics. Then we turn to a discussion of our experiences with Telidon page design, and finally look at how they can be used to control various aspects of instruction.

Instructional Graphics.

To begin with, the term "graphic" requires a comment. To some people, it is employed rather narrowly to mean a graph or a chart. To others, it means anything that a computer can put onto its screen that is not straight text. We use the term in this latter, broader sense, because Telidon pages were used for a number of different purposes requiring the display of a whole range of images from fairly realistic pictures, to diagrams, charts and text.

Underlying the theory concerning the various roles of instructional graphics is the premise that it is advantageous to use visual-spatial representations to communicate ideas. Maps, for instance, are far more efficient at communicating about topography or the layout of a city than a verbal description would be. Graphs and charts can convey in an instance ideas that numbers alone could never convey as well (see MacDonald-Ross, 1977, for many excellent examples). Flow diagrams describe in ways that are easy to understand complex spatial and sequential relationships (Winn and Holliday, 1982; Winn, 1983). In short, by adding visual-spatial representations to the more usual linear-verbal formats, we are encouraging students to bring their whole battery of spatial abilities to bear upon what they have to learn. This will be an advantage for any student, for we all have

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the capability to process information simultaneously as well as successfully (Das, Kirby and Jarman, 1979). It will be particularly advantageous to some who are not very good at learning from the spoken word or from written texts. In this case, the addition of graphics provides alternative forms of representation for those students who need them. As an example, Holliday (1979) has summarized results from a number of studies in science teaching involving visual treatments and various student aptitudes.

A number of writers have suggested schemes by means of which illustrations can be organized for study and for application. These range from semiotic approaches (Knowlton, 1966) to classifications by function (Duchastel, 1978; Duchastel and Waller, 1979; Sless, 1981) where the purpose of the illustration is the criterion of interest. Although semiotic approaches to the study of instructional ilustrations have formed the basis of a number of research programs that have studied the role of realism (the degree to which a representation resembles reality) in instruction (Dwyer, 1972, 1978; Lamberski, 1980; Clark and Angert, 1985), we found it more useful to think of the function of our graphics as we were creating them. And rather than think in terms of a fairly complex scheme, such as the one proposed by Duchastel (1978), we opted for just three functional categories for our graphics: illustration, cueing, and structuring. As with any classification scheme, particularly a simple one, these three categories are not mutually exclusive. Nor do they preclude consideration of realism in design and implementation, as we shall see.

Illustration.

When graphics are used to illustrate something, it is their purpose to show as accurately as possible what something looks like. This is necessary when it is intended that the student learn to identify something by looking at it. Thus, field guides used by naturalists contain illustrations of birds, plants and animals that show all characteristics realistically. However, the temptation to make illustrations as realistic as possible must be resisted. The most effective illustration is the one in which the features of what is illustrated are presented clearly and unambiguously. Often a color photograph shows too much detail, and a drawing is more effective. (This has been the conclusion drawn from a number of studies by Dwyer and his associates concerning the instructional effectiveness of various types of illustration of the human heart. See Dwyer 1978 and Clark and Angert, 1985 for a summary). This is why the best field guides are illustrated with drawings rather than with color photographs.

It is perhaps fortunate for those working with computer graphics that a high level of realism is not required of effective illustrations! At present, computers are not capable of producing pictures of the fidelity that can be achieved by

photographic techniques. This is particularly true of Telidon in the version we had available for our project. The screen resolution, the difficulty of drawing smooth curved lines and the limited number of colors all militate against realistic illustrative graphics.

Be that as it may, we used graphics to illustrate a number of things. First, we included drawings purely for motivational purposes. (This would correspond to Sless's (1981) "attentional" illustrations.) Second, we presented realistic facsimiles of the drawings children had done to illustrate their writing. This served two purposes. It demonstrated a useful technique for getting young children to write, where drawing a picture first and then writing about it is motivational. Second, it illustrated to our students, who were teachers of writing, the kinds of drawings that children should be able to produce to illustrate what they have written. Third, we produced pages that illustrated floor plans of classrooms that would facilitate a variety of activities. In tnis case, the graphics were less realistic in the usual sense of the word, but nonetheless represented to scale the essential characteristics of furniture placement, room dividers, and other relevant aspects of a variety of classrooms.

Cueing.

When the function of graphics is to cue learners, techniques are used that change the relative emphasis the viewers place on different features of what is shown to them. Eye-movement research (Yarbus, 1967, Loftus, 1976) has shown that attention is drawn to and held by those parts of a visual display that in some way stand in contrast to the rest of the picture. Visual cueing, then, draws attention towards certain features of the graphic on the screen and away from other features. (This may be contrasted with simple illustration, discussed above, where the purpose is simply to show something, and not to force the viewer to look at it in a particular way.)

The visual contrast between parts of a graphic, upon which cueing depends, can be achieved in a number of ways: by color, size, flashing, underlining, putting items in boxes, and so on. These effects are usually quite easy to achieve on a computer. We used all of them in our Telidon pages, for the most part successfully. It should be noted that any of these techniques can be applied equally well to text and to non-textual elements in a graphic. Telidon can show letters of different sizes, colors just as easily as varying geometric figures and polygons in the same ways.

The instructional advantages of controlling students' attention by cueing are many. However, for us the main advantages were in pointing out the critical attributes of concepts and in sequencing. A large body of rsearch has led to the conclusion

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that concepts can best be taught by isolating the concept's criterial attributes, such as the elephant's trunk, and that this can be achieved by cueing (see Merrill and Tennyson, 1977, for a summary and application of this research, and Winn, 1981, for a typical study).

As far as sequencing is concerned, we used color cueing of single items, usually in lists, to "lead" students through the material. Thus, the first word in a list would be made up of blue letters, while the other were black. It would be discussed, and then, when the instructor turned to the second item on the list, the second word would change to blue and the first would revert to black. This was repeated through the whole list. This technique applies equally well to leading students through flow diagrams, through tables, or through any graphic where it is important that a certain sequence be observed.

Structuring.

The use of graphics to structure information relies not on a visual similarity between what is shown and real objects, but between what is shown and an abstract, even hypothetical, arrangement of information in a given domain. This is best understood by considering layout, and partic,ularly the distance between pairs of elements in a graphic, as a metaphor for conceptual organization. For example, in the conceptual domain that represents the animal kingdom, cats are thought of as "closer to" lions than to parakeets, and lobsters are thought of as "further away from" gorillas than they are from clams. Thus, a collection of concepts can be organized in terms of the "semantic" or "conceptual distance" among them. (See Preece, 1976, Shavelson, 1974 and Waern, 1972, for examples of techniques for mapping conceptual domains in this way.)

Graphics can represent this space quite literally in the way the representations of concepts are laid out on the screen. In our example from the animal kingdom, cats and lions might be placed in a cluster together in one corner of the screen, with parakeets in another, gorillas in another and clams and lobsters in yet another. This technique is effective instructionally because students expect that ideas that are related through spatial proximity are related conceptually. The effectiveness of graphics derived from the spatial mapping of conceptual domains has been demonstrated in studies by Winn (1980) and Thro (1978).

Graphics may also be used in this way to show the structure of abstract domains. Among these might be block diagrams of the American system of government, flow diagrams of biological cycles (see Holliday, 1976; Holliday, Brunner and Donais, 1977), or, in the case of our project, models of human communication, sentence structure, and instructional planning procedures. The graphic representation of abstract problems and procedures has been shown

to be advantageous to the learner (Johnson-Laird and Steedman, 1978). It has proven to be an effective instructional technique for a number of teachers, and was so in our project.

Designing Telidon Graphics.

We now turn to the matter of our computer graphics. It is not possible to present and discuss all of the issues that arose out of our trying to apply design principles within the constraints imposed by the technical limitations of our system. We have selected those issues to do with illustration, cueing and structuring that we feel were the most important to us, and which we expect to be of interest to others engaged in similar projects. We end this section with a look at how computer graphics permit instructors various kinds of control over information that is lacking in regular teleconferencing. However, we begin our discussion with a more fundamental matter, that of screen legibility.

Legibility.

The Telidon monitor was designed to be viewed by one person at a time. However, since our teleconferencing centers had up to twelve enrolled students viewing one monitor, (although usually there were far fewer in each center), it was necessary to adjust text size and color combinations in order to make the graphics legible. There are four text sizes available on our Telidon system, each of which can be single height or double height. For our purposes, text size 2 was the most effective for regular text. For titles, we usually used text size 2 in double height. Text size 2 in single height allows 31 characters across the screen and 15 lines of print. This text size in double height also permits 31 characters on a line, but only seven lines on a screen. We also found that the single height text lost much of its legibility when it was not double spaced, which, of course, reduced the number of characters per line by half. The smaller text size was not readable from any distance.

Thus, when computer graphics are used to teach groups of students, only the larger text sizes, double spaced and maybe double height, will be legible. Using larger text sizes, however, greatly reduces the amount of information which can be displayed. Also, the larger sizes of text lose some of their clarity, at least on our version of Telidon, because of the low resolution of the system. This is because the larger letters are simply smaller letters enlarged, with the result that the irregularities in diagonal and curved lines which are not noticeable in small text sizes become exaggerated and very noticeable with the larger sizes. The letters look chunky and diagonals are step-like which makes them less easy to view.

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We also found that some combinations of background and text color were more legible than others. Reynolds (1982) explains why this is so in terms of luminance and the acuity of the human eye:

> If white is regarded as having a luminance of 100%, then green has a luminance of 59%, red 30%, and blue 11%. Thus yellow has a luminance of 89% (green plus red), cyan 70% (green plus blue), and magenta 41% (red plus blue). ... When the eye is light adapted, ... it is maximally sensitive to wavelengths in the yellow/green area of the spectrum. Yellow is only 90% as efficient a stimulus as green, orange 80%, and red only 6%. Blue in particular tends to have a lower subjective brightness than other colors, especially when viewed against a dark background. ... Acuity is highest for white and green light. Our resolving power for red is only about one third of that for white, and for blue it is only about one fifth of that for white. (p. 422).

The brightness and clarity of different colors varies enormously, and this is precisely what we observed.

The following table lists some of the color combinations which were found to be effective for text.

Background Color	Text Color
Black	Yellow Green
Dark Grey	Cyan Yellow Green
Medium Grey	Yellow White
Blue	White

Other background colors, such as yellow, cyan, light grey and red were tried, but appeared to flicker on our monitors, and were quickly abandoned. The most successful background color was dark grey rather than black. The available colors are white, yellow, cyan, green, magenta, blue and black. The luminance values of the greys correspond to the luminance values f these colors. That is, the grey which corresponds to yellow on the scale would be very light, while the grey corresponding to blue would be exceedingly dark. The greys corresponding to the red or blue tones on the color scale were most frequently used as backgrounds for both text and graphics.

Illustration.

Graphics were used to illustrate as realistically as possible a number of types of information. In the grammar course, for example, they were used to convey how punctuation can change the meaning of a sentence. Pictures illustrated the two sentences: "Leo, the zookeeper, is locked in the lion's cage", and "Leo, the zookeeper is locked in the lion's cage." Leo was drawn inside the cage for the first sentence and outside the cage for the second one. The intent here was to illustrate how omitting one comma could change the meaning of the sentence, and to demonstrate to the students that the technique of using drawings to illustrate points of grammar could be used by them in their own classrooms.

Graphic illustrations were also used to visualize (and thus make more interesting) such things as children's responses on a listening questionnaire. Statements such as, "When my Mom is listening, she always looks kind of puzzled", can be brought to life with an appropriate graphic.

Examples of drawings made by children to illustrate what they had written could often be faithfully reproduced as Telidon pages. For our purposes, this type of graphic was used to show the kinds of drawings children typically add to their sentences and stories, and also to show that the teaching technique itself had been successfully implemented in the classroom.

Less realistic graphics, composed largely of line drawings, were used to show physical arrangements of classrooms, learning centers, carts and work stations, and samples of contracts, work sheets, bulletins and bulletin boards. This type of illustration was found to be particularly valuable in the classroom management course.

When we developed these graphics, some compromises had to be made. Cartoon-like drawings were used rather than more realistic representations. In addition to the limitations of the system when it came to creating realistic illustrations, the two reasons

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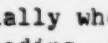
for this were screen size and the amount of time it took for a graphic to build up on the screen. Almost every graphic contained some text -- a title, a sentence, a label. Since, as we said earlier, the text had to be large enough to be legible, this further reduced the screen area available for the graphic. Simplified line drawings were easier to fit into this reduced space Also, more complex images took longer to appear on the screen, especially when grid patterns () were used to simulate shading. At 1200 baud, even a simple Telidon page takes two or three seconds to be transmitted and to build up on the screen. Moreover, with the present system, the instructor cannot talk to the students while a graphic is being transmitted. Therefore, it was preferable to use simple graphics that appeared quickly than to have longer periods of "dead air" that would be the result of transmitting more complex illustrations.

Cueing.

Highlighting and cueing took many forms. Titles and important concepts were boxed, circled, or underlined. We found too that the boxing of titles and even whole pages gave a sense of unity to the graphic.

Color coding was used to highlight text phrases or to cue students to new information. When used for these purposes, it was found to be most effective when the colors were limited to two or at most three. The color used for highlighting was brighter than the other colors. The color combination used most frequently for this were cyan for the main color and yellow for the highlighted text.

Lists that were presented one item at a time often used a color coding technique to highlight the new information. The first item on the list would be shown in yellow. Once it had been discussed, the second item would be transmitted. During the transmission, the first item would change to cyan while the second would appear in yellow. After discussion, the next item would be transmitted in yellow, and the previous item would change to cyan. In this manner, all items would be available for reference, but the item being discussed would stand out on the screen. Students were "led through" the list in the intended order.

In the grammar course, the section on sentence combining took advantage of various other cueing techniques. Key words were in upper case. Words that were to be omitted in the combined form of the sentence were crossed out with an X. Hints were given in brackets beside the sentences. The techniques were all ones that the students would be able to use later, in paper and pencil form, in their own classrooms. (This was one of the reasons that cues like blinking were not used with this type of exercise.)

Structuring.

The sequential structuring of information was achieved primarily in two ways. First, we took advantage of the relative slowness of the transmission of graphics and varied the order in which items appeared. Second, we used the "overlay" facility of Telidon, where a new graphic can be superimposed on one that is already on the screen.

For pages that contained both text and pictorial material, the order in which the page was built up on the screen was tied to the particular goal of the instructor for that portion of the class. An example from the grammar course where the text appeared before the graphic is in the sentence combining activities. Here, it was felt that while students were working out the combined form of two simple sentences they could be treated to a graphic simply for their enjoyment. However, one series of pages in the classroom management course presented the pictures first. For the section on management styles, the graphic appeared first, giving the students the chance to see if they could guess the management style from the graphic prior to the title appearing.

Overlays were frequently used to build up lists or graphic representations of models in a sequential manner. They were used in much the same way as one would use overlays on an overhead projector. The base page was transmitted first. Once discussion of the page was completed, each "overlay" would be transmitted and added, under the control of the instructor, in concert with the discussion.

Overlays were also used to build up non-textual material. In the unit on sentence expansion in the grammar course, not only was the sentence itself expanded through the use of overlays, but the illustration also expanded at the same time. Again, the purpose was to reinforce the combining process through additive illustration, and also to show the students the kinds of drawings they could have their own students do as they worked on their grammar exercises.

Another technique employed was that of having blanks on the screen that could be filled in, in any order, with appropriate words or phrases on separate overlays. This proved to be an effective inductive technique, and, once again, could be used later by the students in their classrooms with overhead transparencies.

Our use of spatial structuring of information through graphics followed pretty standard principles for any graphic design. Models of human communication and of instructional planning were diagrammed in such a way that the distances between elements was itself meaningful. Clustering of the parts making up subsystems of interpersonal communication was enhanced by the surrounding them with boxes and by distinguishing them from other

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subsytems by using a distinctive color for each.

In the grammar course, some topics were boxed while related concepts were circled and scattered on the page. The circles were used to indicate that a complete idea was enclosed within each. The scattered format was used to indicate that no concept was more important than another. For example, under the topic of writing format, the related concepts "letter", "story", "diary", and "news story", had equal value.

Instructor Control.

As noted earlier, the use of the Telidon system of graphic enhancement is advantageous to students, since it not only encourages them to bring their whole battery of spatial abilities to bear on what they are learning but also provides them with forms of representation other than the spoken word. We found in this project that the use of computer graphics is also advantageous for instructors, since it allows them to illustrate and augment aural presentations, and permits them control over the presentation of information that is not generally available in teleconferencing. This control takes place in a number of ways.

Since Telidon is a sequential medium with each page of information accessed one after the other, the instructor has total control over the order and speed at which material is provided to students. Control of pacing means that all students can be kept at the same point in a teaching sequence. This is not possible when supplemental information is provided in the form of handouts or other types of readings, since the instructor cannot control how much or how often students read ahead.

Control of information order allows for inductive teaching, using such techniques as questioning, brainstorming, and problem solving. Incomplete information can be provided by the instructor using Telidon pages, discussion concerning what is needed to complete the information can be initiated; additional information to complete the concept or provide the correct answer can be presented. Since suspense can be built in this way, motivation can be enhanced. The overlay function of Telidon is useful in this regard, since simple concepts can be developed as details are added at a pace the instructor senses is appropriate based upon knowledge of the students. This knowledge, as well as feedback concerning the need to vary the pace at which information is presented, is available from the instructor's interaction with the students over the teleconference system.

Teleconference instructors often involve students in small group activities at the individual centers. We found it useful to leave appropriate graphics on the screen for student use during these workshop activities. In this way, we were able to individualize, as well as to provide for reinforcement where

necessary.

Ease of information access is another important feature of our system. Once pages have been numbered and placed in the database, it is a simple matter for the instructor to access them at any time and thus to control not only initial information presentation but also review. This facilitates the use of graphics as advance organizers, outlines, and comprehension checks. (It also prevents misplacement or loss of graphics, which is not an unusual occurrence with overhead transparencies!)

Learners make use of a number of organizational patterns as they work through, comprehend, and apply new concepts. These can involve their interpreting information on the screen as simple lists, time sequences, cause and effect relationships, and the like. The ways in which the instructor manipulates the order in which the pages are presented can facilitate students' use of each of these patterns.

Since, in our project, the instructors were intimately involved in the design of the graphics, instructor control over the presentation of information could be exercised at this very fundamental level too. In a very real sense, our instructors were able, through the variety of cueing, attention-directing and sequencing techniques described above, to control fairly precisely the way in which students perceive and subsequently process the information presented to them graphically. For us, this observation stresses the importance of having instructors, as subject-matter specialists, work very closely with the graphic designers at every step of the design and revision process. Without this close cooperation, much of the potential of the graphics for effective instruction will be lost.

In summary, instructor control of student access to information through the use of Telidon in teleconferencing can be exercised in at least the following ways: 1) Instructors can control the order in which the material is presented; 2) They can control the pace at which the material is presented; 3) They can control to a degree the way in which students perceive and process the information; 4) They can use the pages to vary both instructor and learner strategies; and 5) They can use graphics for initial presentation of concepts as well as for development and review.

Conclusion.

The Telidon system lends itself well to the presentation of simplified graphic materials for illustration, cueing and structuring. Because of limitations imposed by text size when the monitor is used with groups of students, more complex and detailed graphics would be illegible. However, simple lists, charts, forms, line drawings, cartoon-like pictures, models and

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tree structures can be effective in this medium. Even horizontal and vertical split screens work well as long as there is not an overabundance of text. The use of numbers, arrows, boxing and spacing can indicate sequences and conceptual relationships quite well on our system.

The major thing we learned in the designing of computer graphics for Telidon for use with groups of students can be summed up in one word -- simplicity. Telidon's colors are clean and vibrant. They should be used sparingly, expecially on pages composed solely of text. The amount of text shouldd be kept to a minimum, meaning that lists and point form should be used whenever possible. Nor should the message in the text be overpowered by the pictorial material. This, like text, should be kept simple.

As more sophisticated computer graphics systems become available, with a greater variety of colors and primitives, more complex animation, and better screen resolution, we expect that some of our comments, concerning such technical matters as legibility, will no longer apply. However, we do believe in the validity of what we have said about the ability of computer graphics to enhance spoken instruction, particularly when there is no face-to-face contact between student and instructor. We found that the functional approach to illustrations was most helpful in conceptualizing and designing our graphics. We found empirically based principles concerning illustration, cueing and sequencing to be useful, although they needed to be adapted on occasion to suit our system. We found our use of graphics to control the flow of instructional activities to be very effective. The observations we have made in this paper will certainly be relevant to anyone beginning a project where computer graphics are used to enhance spoken instruction. We also hope that these guidelines will be useful to anyone researching computer graphics in a more general sense. We expect that, eventually, our rather informal study may help others form research hypotheses about the effectiveness of computer graphics that can be tested more rigorously at some time in the future.

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